Grade Level/Course: _Algebra 1

Lesson/Unit Plan Name:
Exploring Quadratics Graphs

Rationale/Lesson Abstract:
This lesson has students exploring the effects of various transformations to the parent graph of the parabola by plotting points and graphing each type of transformation.

Timeframe:
The introductory lesson should take 1-1.5 class periods. Depending on class discussions and student interactions.

Common Core Standard(s):

F-IF 7a: Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

a. Graph linear and quadratic functions and show intercepts, maxima, and minima

The extension of this lesson leads to the following standards.

F-IF 8a: Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function

a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.

A-SSE 3a

Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression:

a) Factor a quadratic expression to reveal the zeros of the function it defines.

Instructional Resources/Materials:

1. **Use projector to show the lesson to the class.**
2. **Make copies of pages 6 – 8 for each student.**

Activity/Lesson:

Part 1. Think-Pair-Share

a. The lesson starts with the teacher showing the graph of two lines and asking students what is similar and different about the two graphs. Student should be given a couple of minutes to think on their own, the teacher should then have students share their ideas with their partners. After another minute or two, the teacher should ask the class for their responses. The teacher should ask for as many responses as possible. The graphs have different slopes and y-intercepts and the same x-intercept.

b. The teacher should then show the second graph. This shows a line and a parabola graphed on the same axis. Students are again asked what is similar and different about the two graphs. Student should be given a couple of minutes to think on their own, the teacher should have students share their ideas with their partners. After another minute or two, the teacher should ask the class for their responses. The graphs have different y-intercepts and they share an x-intercept. The students may also notice that the line has a negative slope and the parabola in both increasing and decreasing and has a minimum value called a vertex. The parabola is symmetric and that the parabola has two x-intercepts. The teacher should elicit and/or tell the students all of this if the class doesn't come up with it and that the curved graph is called a parabola.

Part 2. We do-They do-You do

a. We then complete the table for the parent graph of $y=(x)^2$. We make notice of the vertex at (0,0).

Then we complete the tables for both $y=\frac{1}{2}(x)^2$ and $y=2(x)^2$. Ask the students what is the effect of multiplying the parent graph by ½ and 2 respectively. After student responses, tell them that these are usually called vertical stretches and/or shrinks. The vertices of each of these parabolas is (0,0).

b. Have the student work in small groups/pairs and complete the next set of tables and then graph $y=(x)^2$, $y=-\frac{1}{2}(x)^2$, and $y=-2x^2$. Walk the classroom, helping and prompting the students to complete the table, graph the parabolas, and answering the questions about the effect of multiplying the parent graph by -1/2 and -2 respectively. After student responses, tell them that we again have vertical stretches and/or shrinks and a reflection about the x-axis. The vertices of each of these parabolas is again (0,0),

c. Leave the students in small groups/pairs, have them attempt the next set of tables and then graph $y=(x)^2$, $y=(x)^2-4$, and $y=(x)^2+3$. Students may struggle with this step, so walk the classroom, helping and prompting the students to complete the table, graph the parabolas, and answering the questions about the effect of adding -4 and +3 to the parent graph. After student responses, tell them that we again have vertical shift either up or down from the origin. The vertices of each of these parabolas is (0,0), (0,-4), and (0,3) respectively.

d. Have the class work together to complete the next set of graphs. We will complete the tables for $y=(x)^2$, $y=(x-2)^2$ and $y=(x+3)^2$ as a class. Ask the students what is the effect of adding -2 and +3 inside the parenthesis. After student responses, tell them that these are usually called horizontal shifts. This transformation is the most difficult for students to understand. A good way to get students to see the shift is to ask the question "What makes the parenthesis equal to zero." In some advanced math classes this is called the "argument". The vertices of each of these parabolas is(0,0), (2,0), and (-3,0).

Part 3. Extension/Abstraction: Questions 5-6-7 and Ticket out the door.

a. Question 5 asks students to match the graphs of three different types of transformations with their respective equations.
b. Question 6 asks students to put the several parabolas in order from most narrow to the widest and to circle all of the parabolas that open downward.
c. Question 7 asks students to identify the vertices of several parabolas that demonstrate each of the transformations explored today.

Part 4. Ticket out the door.

a. Students are asked to identify the vertices of several parabolas that have each of the transformations demonstrated today, and also one parabola that has all three transformations.

Activity/Lesson continued:

The follow up to this lesson could be:

1. Discuss with students a plan to graph parabolas in this form. They should identify the vertex and then plot 3-5 points centered around the x-coordinate of the vertex.

2. Some teachers like to share with students the quadratic pattern that exists around the vertex of each parabola. (Over one-Up one, Over two-Up four, Over three-Up nine.

3. Other teachers like to share with students that the line of symmetry of the vertex is of the form $x = \frac{-b}{2a}$. This is then identified as the x-value of the vertex. Once that is identified students can then substitute that value into the equation to find the y-coordinate of the vertex. We now have the vertex. Once this is found we can then find 3-5 other points by plotting points or using the quadratic pattern. The equation for the line of symmetry comes from the quadratic formula:
$$x = \frac{-b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a}$$

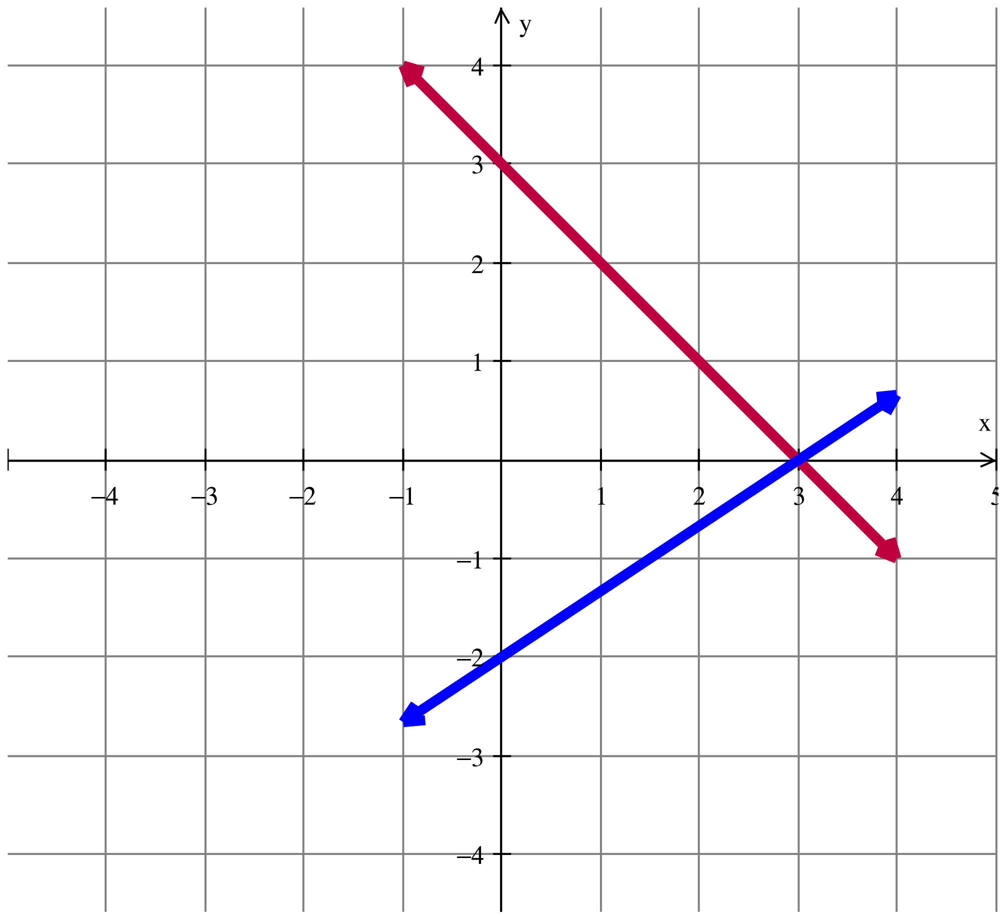
Assessment:

Questions 5-6-7 were included to help solidify student understanding of this lesson. The Ticket out the door is to be used by the teacher to gauge individual student understanding by the end of the lesson.

a. Students should be asked to graph each type of transformation for homework that evening by completing a table of values centered around the x-coordinate of the vertex.

b. The next day, I would answer the ticket out the door questions as a class. Then I would ask the class to answer questions similar to questions 5-6-7 in this lesson.

Comparing graphs



What is similar and different about the two graphs?

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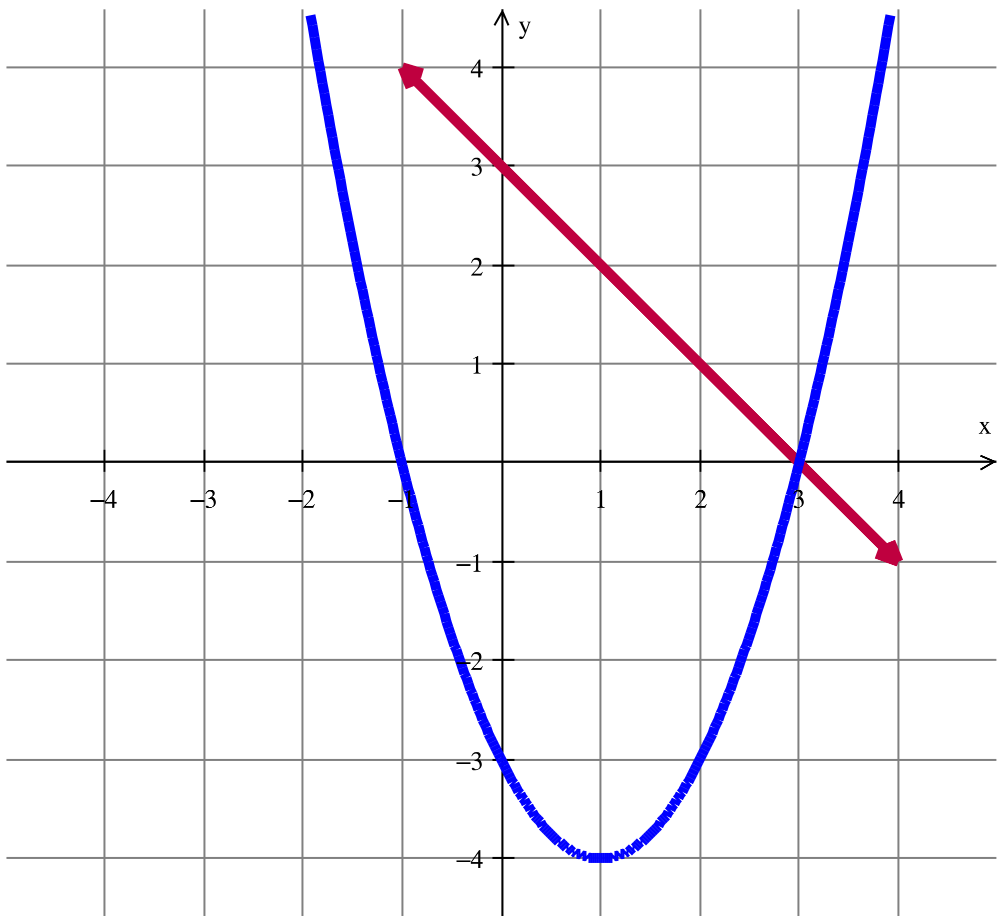
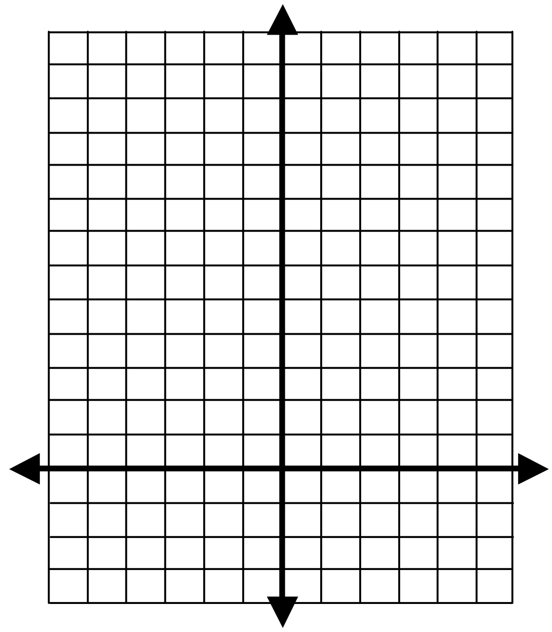


What is similar and different about the two graphs?

Graphing Quadratics

1. Complete the table of values and graph.

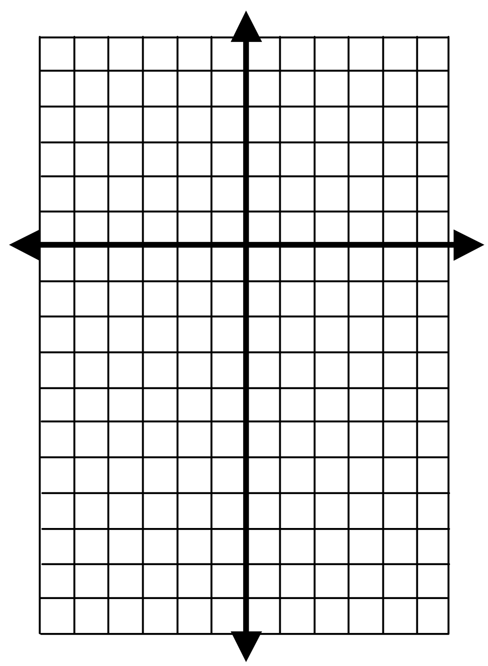
x	$y=(x)^2$	$y=\frac{1}{2}(x)^2$	$y=2x^2$
-2			
-1			
0			
1			
2			



What was the effect of multiplying $y=x^2$ by $a=\frac{1}{2}$ and $a=2$? What is the vertex of the parabolas?

2. Complete the table of values and graph.

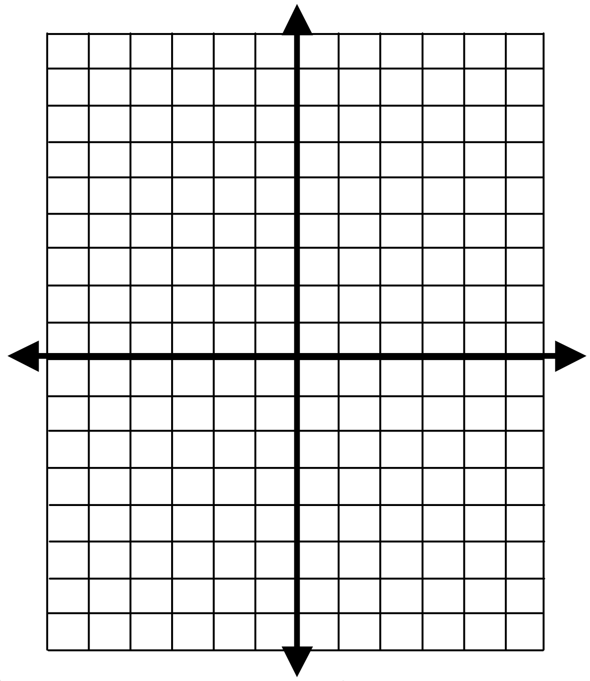
x	$y=(x)^2$	$y=-\frac{1}{2}(x)^2$	$y=-2x^2$
-2			
-1			
0			
1			
2			



What was the effect of *multiplying* $y=x^2$ by a = - $\frac{1}{2}$ and a = - 2? What is the vertex of these parabolas?

3. Complete the table of values and graph.

x	$y=(x)^2$	$y=(x)^2-4$	$y=(x)^2+3$
-2			
-1			
0			
1			
2			



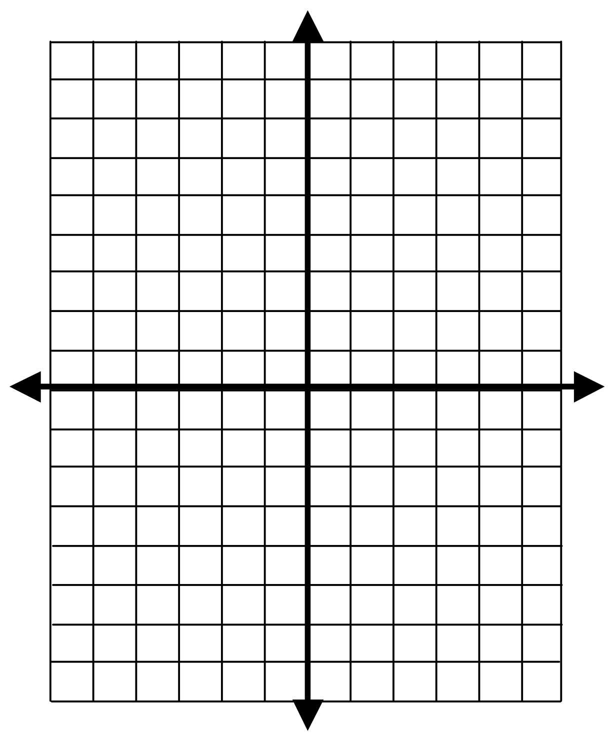
What was the effect of *adding* k = -4 and k = 3 to $y=x^2$? What is the vertex of these parabolas?

4. Complete the table of values and graph.

x	-2	-1	0	1	2
$y=(x)^2$					

x	0	1	2	3	4
$y=(x-2)^2$					

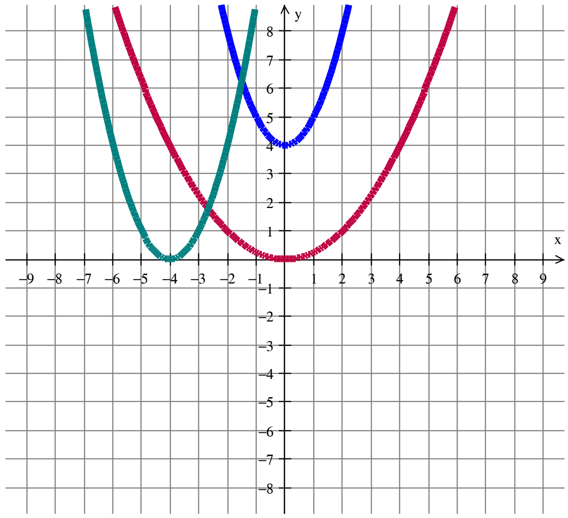
x	-5	-4	-3	-2	-1
$y=(x+3)^2$					



What was the effect to $y=x^2$ *by adding* h = -2 and h = 3 inside the parenthesis? What is the vertex of each parabola?

5. Match the following equations to the corresponding graph.

a. $y=\frac{1}{4}(x)^2$ b. $y=(x)^2+4$ c. $y=(x+4)^2$



What was the effect of each transformation to the parabolas? What is the vertex of each parabola?

6. Put the following parabolas in order from most narrow to the widest. Circle all of the parabolas that open down.

a. $y=3(x+3)^2$, $y=-9(x)^2$, $y=\frac{1}{3}(x)^2$ b. $y=-\frac{3}{2}(x)^2+1$, $y=9(x)^2$, $y=-\frac{2}{5}(x)^2$

7. Identify the vertex for the following parabolas.

a. $y=2(x+1)^2$ b. $y=-8(x)^2+6$ b. $y=\frac{1}{3}(x)^2$

Ticket out the door:

What are the vertices of the following parabolas?

$$y = -3(x)^2$$

$$y = (x)^2 + 9$$

$$y = (x-1)^2$$

<u>Bonus Question</u>

$$y = -2(x+2)^2 + 2$$